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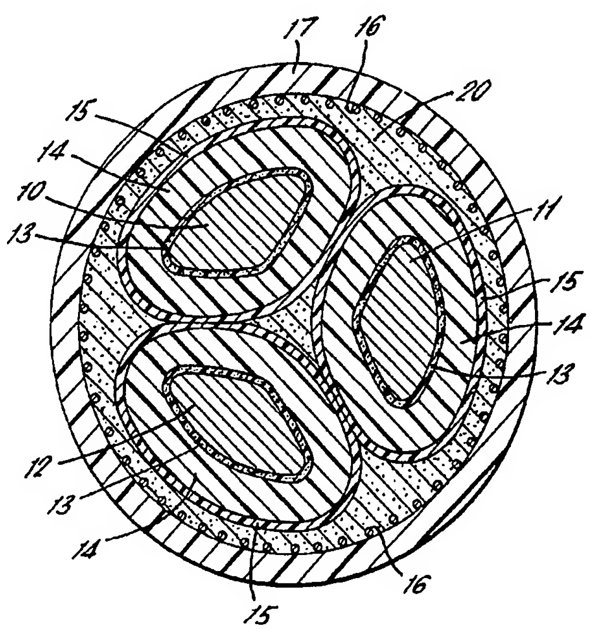
(54) Electric power cable

(57) An electric power cable comprises one or more current conductors 10, 11, 12, a semi-conductive screen 13, a semi-conductive layer 15 constituting the core screen, an insulating polymeric layer 14 and a metallic screen 16. Water-absorbing uncoated montmorillonite clay and/or molecular sieves 20 is provided between the outer sheath 17 and the core screen or screens. The clay may be a dried mixture of calcium montmorillonite (Fullers earth), a depolymerised butyl rubber, mineral oil or paraffin wax, calcium carbonate and carbon black. The use of the montmorillonite clay and/or molecular sieves avoids the problems arising from the employment of materials, such as have been used heretofore, which may exacerbate water treeing and cause corrosion of metallic parts.



The drawing(s) originally filed was/were informal and the print here reproduced is taken from a later filed formal copy.

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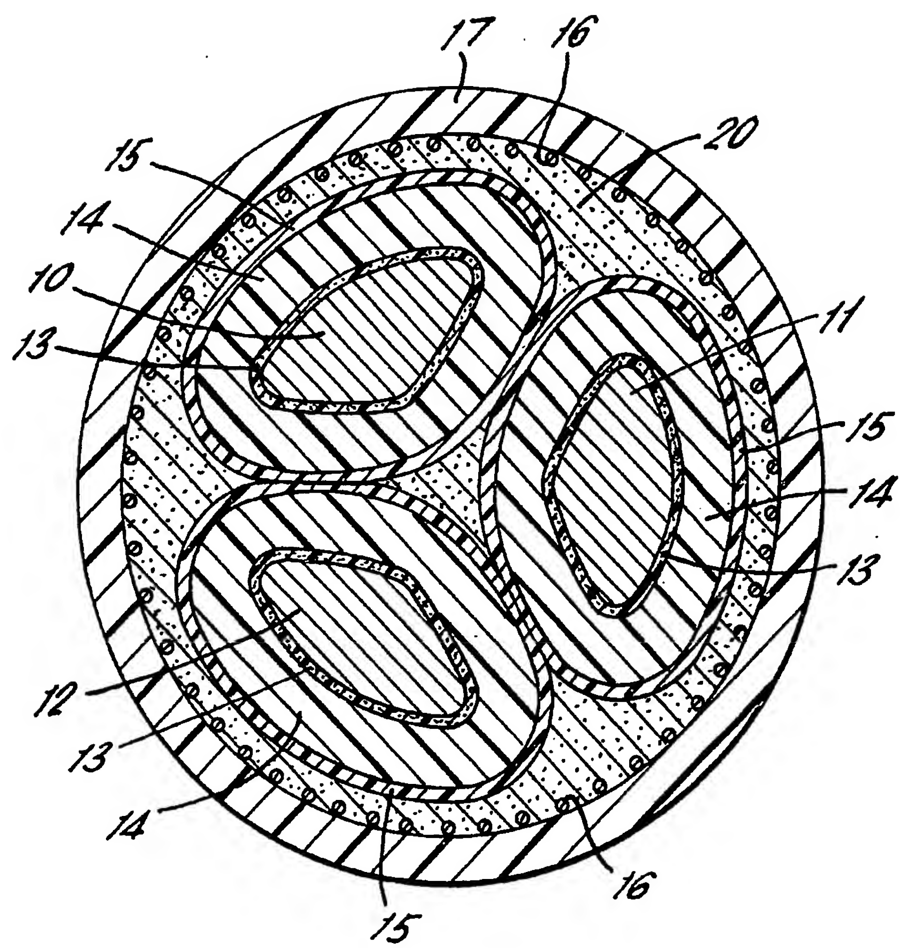

SPECIFICATION

Electric power cables

This invention relates to electric power cables.

The traditional way of keeping water out of underground electric power cables has been to use an impermeable sheath, commonly a seamless aluminium or lead sheath. Such sheath materials are essential for example to protect the paper insulation of high voltage paper insulated cables from water uptake, which leads to chemical and electrical degradation.

With the introduction of polymeric insulation, e.g. uncross-linked polyethylene or cross-linked polyethylene (XLPE) or ethylene-propylene rubber (EPR) for the insulation of high voltage cables it was not at first appreciated just how deleterious was the presence of water in or around the insulation. Consequently impermeable metal sheaths were not considered to be necessary; the non-metallic-sheathed polymeric cables had the advantages of lighter construction, lower cost and relative ease of jointing compared with metallic-sheathed cables.

Even if a metallic sheath was provided on a polymeric insulated cable, there was still a risk of mechanical damage leading to water ingress. One such damage has occurred or if water enters a faulty joint, there is axial flow of water since there has to be a sheath clearance to accommodate core expansion.

Following the widespread introduction of polymeric insulated cables in certain countries in the mid 1960's, there has been a widely publicised problem of cable failures and its possible association with the phenomenon of "water-treeing". This arises from condensed water in the insulation. The water must be derived from the outside environment or taken up during cable manufacture. Various methods of counteracting water-treeing have been considered. A seamless metallic sheath, together with a dry insulation, in the absence of mechanical damage, is a sure way of preventing water-treeing if radial diffusion from the outside is the only source of water. The use of organic and inorganic additives to the insulation to inhibit the occurrence of water-trees have been tested but none has proved entirely successful.

According to the present invention an electric power cable comprises one or more current conductors, the or each conductor having a surrounding conductor screen with polymeric insulating material around the conductor screen and a core screen around the polymeric insulating material, an outer sheath surrounding said one or more conductors with their insulation and screens, a metallic screen between the core screen or screens and the outer sheath, and also, between the core screen or screens and the outer sheath, a fine particulate humidity-reducing material comprising a water-absorbing uncoated montmorillonite clay and/or molecular sieves. The montmorillonite clay may be for example calcium montmorillonite (commonly known as Fullers earth) or sodium montmorillonite (bentonite). Preferably calcium montmorillonite is used as it has better water-absorption properties than sodium montmorillonite. Unlike bentonite used for thickening oils, e.g. mineral oils to form water-resistant greases, the montmorillonite is uncoated as the humidity-reducing material is water-absorbing and has to be hydrophilic. Instead of or in addition to the montmorillonite clay, molecular sieves may be used.

The use of a montmorillonite clay and/or molecular sieves avoids the problems arising from the employment, such as has been proposed heretofore, of deliquescent salts such as magnesium chloride or calcium chloride or lithium chloride which may exacerbate water treeing and cause corrosion of metallic parts. It also avoids the problems of micronised silica gel, which is another material heretofore proposed for use as a water-absorbing material in cables, which material is readily fouled by low molecular organic compounds. The water-absorbing particulate material is preferably blended in an organic carrier medium to form an extrudable mixture or paste. The carrier medium may be a viscous organic fluid or a rubbery semi-solid. A typical carrier is unvulcanised or reclaimed depolymerised butyl rubber or polyisobutylene. Additionally a plasticiser or a mixture of plasticisers, e.g. DOP, mineral oil, paraffin wax may be blended into a carrier. Other additives such as filler material, antioxidant or tackifier may be included. It is preferred that this humidity-reducing layer should be semiconductive and, for this reason, carbon black and/or graphite may be included.

A montmorillonite clay not only has the small particle size desirable for this extrudable material but is a material which has high water absorbing properties and swells as water is absorbed. Molecular sieves on the other hand do not swell. The montmorillonite clay therefore is advantageous in that, if any water enters into the cable through damage or at a joint, it causes the humidity-reducing layer to swell so filling any pores in the layer of humidity-reducing material or any voids between the cores and the outer sheath so blocking axial flow of water.

The metallic screen between the core screen or screens and the outer sheath, which constitutes the "collective" screen in the case of a multicore cable, and which is provided to carry fault currents, may be immediately between the humidity-reducing material and the other sheath or may be within the humidity-reducing material or may be between the core screen or screens and the humidity-reducing material.

The metallic screen may be of wire or tape or may be a seamless extruded metal screen.

The outer sheath preferably is of a plastics material. It is selected to restrict the rate of moisture ingress to the lowest practicable value. For this reason, polyethylene, more particularly high density (about 0.96 g/cc) or medium density (about 0.94 g/cc) are preferred to polyvinylchloride. Seamless metallic sheaths or bonded

metallic tapes may be used but, in general, these are not essential.

The following is a description of one embodiment of the invention, reference being made to the accompanying drawing which is a schematic cross-section of a three-core high voltage power cable.

Referring to the drawing the cable illustrated has three conductor cores 10, 11, 12 which, in the known way, are of a generally sectorial shape and are formed in the known way typically of copper or aluminium. Each conductor is surrounded by a conductor screen 13 of semiconductive material, typically made from cross-linked polyethylene containing semiconductive particles, for example carbon black. Around the conductor screen, each core has an insulating layer 14 of polymeric material, typically a polyethylene compound or a cross-linked polyethylene compound or an ethylene propylene rubber compound. This insulating layer for each core is surrounded by an outer semiconductive layer 15 constituting the core screen which is applied as a tape around the core or as a coextruded thermoplastic or as a coextruded cross-linked polymer.

Around the three cores is a metallic screen 16 formed of copper or aluminium wires or tapes with an outer jacket or sheath 17 of polymeric material, e.g. a polyvinylchloride compound or more preferably a polyethylene compound.

The present invention is concerned more particularly with humidity-reducing material 20 provided in the region between the cores inside the metallic screen 16 and possibly also between the metallic screen 16 and the outer sheath 17. This humidity-reducing layer comprises an extrudable rubbery material containing, in this particular example, calcium montmorillonite. An extrudable carrier material was formed consisting of a mixture of:-

Depolymerised butyl rubber	100 parts by weight
Mineral Oil/Paraffin Wax	45 parts by weight
Calcium Carbonate	100 parts by weight
Carbon Black	85 parts by weight

This carrier material was blended with 131 parts of a dry natural calcium montmorillonite clay on a rolling mill. The calcium montmorillonite was "Surrey Finest", obtained from Laporte Industries Limited. The average particle size was < 20μm.

In order to determine the efficiency of this material in taking up water, a 0.69 mm thick sample of fully compounded carrier material was cut and was equilibrated with dried silica gel at 80°C to remove water picked up during blending. (In practice *thorough* drying of the components will not be necessary, since complete removal of water is not absolutely essential, but the drier the pre-blended components, so much the better). The sample was then conditioned in a humidity oven set at 65% relative humidity and 25°C. The water uptake of the experimental compound was 3.59g/100g dry compound. Assuming that almost all of the water was adsorbed by the clay this is equivalent to 12.6gH_2O/100g dry clay. An adsorption experiment on the undiluted clay gave an equilibrium water uptake of 14.8g/100g dry clay. The "efficiency" of this particular compound was thus (12.6/14.8) × 100, i.e. 85%, the reduction from 100% being due to the restraining influence of the organic binder.

In forming the cable the humidity-reducing material is extruded to lie between the core screens 15 and the outer sheath 17 so as to fill as far as possible all the voids between the cores and the outer sheath. The material may be extruded as one layer with the metallic screen 16 put around it and the outer sheath 17 extruded directly around the metallic screen or there may be a further extruded layer of humidity-reducing material between the metallic screen 16 and the outer sheath 17. Alternatively the metallic screen may be put between the core screen or screens and the humidity-reducing material.

Although sectorial shaped cores are illustrated, the cores may be of other section, e.g. circular, and they may be of stranded or solid or other construction.

CLAIMS

1. An electric power cable comprising one or more current conductors, the or each conductor having a surrounding conductor screen with polymeric insulating material around the conductor screen and a core screen around the polymeric insulating material, an outer sheath surrounding said one or more conductors with their insulation and screens, a metallic screen between the core screen or screens and the outer sheath and, also between the core screen or screens and the outer sheath, a fine particulate humidity-reducing material comprising a water-absorbing uncoated montmorillonite clay and/or molecular sieves.

2. A cable as claimed in claim 1 wherein the montmorillonite clay is calcium montmorillonite or sodium montmorillonite.

3. A cable as claimed in either claim 1 or claim 2 wherein the water-absorbing particulate material is blended in an organic carrier medium to form an extrudable mixture or paste.

4. A cable as claimed in claim 3 wherein the carrier medium is a viscous organic fluid.

5. A cable as claimed in claim 3 wherein the carrier is a rubbery semi-solid.

6. A cable as claimed in claim 3 wherein the carrier is unvulcanised or reclaimed depolymerised butyl rubber or polyisobutylene.

7. A cable as claimed in any of claims 3 to 6 wherein the carrier includes a plasticiser or a mixture of

plasticisers.

8. A cable as claimed in any of claims 3 to 7 wherein the carrier includes a filler material and/or an antioxidant and/or a tackifier.

9. A cable as claimed in any of the preceding claims wherein the humidity-reducing material is semiconductive.

10. A cable as claimed in claim 9 wherein the humidity-reducing material includes carbon black and/or graphite.

11. A cable as claimed in any of the preceding claims wherein the outer sheath is of polymeric material.

12. A cable as claimed in claim 11 wherein the outer sheath is of polyethylene.

13. A cable as claimed in any of the preceding claims wherein the metallic screen is between the core screen or screens and the humidity-reducing material.

14. A cable as claimed in any of claims 1 to 12 wherein the metallic screen is between two layers of the humidity-reducing material.

15. A cable as claimed in any of claims 1 to 12 wherein the metallic screen is between the humidity-reducing material and the outer sheath.

16. An electric power cable substantially as hereinbefore described with reference to the accompanying drawing.

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